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A SUMMARY OF THE STUDY OF MILK COMPOSITION IN ONTARIO 1961-1965

ONTARIO DEPARTMENT OF AGRICULTURE & FOOD

Parliament Buildings, Toronto

EVERETT BIGGS / DEPUTY MINISTER HON. WM. A. STEWART / MINISTER

A SUMMARY
of
The Study
of
MILK COMPOSITION
in
Ontario

This study was conducted in Ontario, 1961 - 1965, by the Dairy Branch of the Ontario Department of Agriculture and Food, the Departments of Dairy Science and Animal Science of the Ontario Agricultural College, the Department of Veterinary Bacteriology of the Ontario Veterinary College and the Production and Marketing Branch of the Canada Department of Agriculture.

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INTRODUCTION

During the past half century dairying has been transformed from a simple farmer-consumer business to a highly organized, diverse and complicated industry processing and marketing a multitude of dairy products. Development of the industry during this period has been influenced to a major extent by the fat portion of milk. Early recognition of the contribution of milk fat to flavor, plus the discovery of a practical fat test, led to its acceptance as a controlling factor in the price structure. The consequences of this have been manyfold. Most selective breeding programs in the past have been aimed at increasing fat production. Regulations regarding dairy products have nearly all included specific minimum standards for fat content. Fat production records of purebred dairy cows have contributed largely to their sale value as breeding stock, both in domestic and foreign markets. Under these conditions testing for fat permeated every section of the industry, followed by a general belief that fat is the most important ingredient in dairy products.

During the same half century dietary trends have gradually but unmistakably changed. Improved methods of communication such as radio and television, which combine entertainment with a profusion of various kinds of advertising, and the advent of the supermarkets, have resulted in a much closer contact between the seller and the buyer. Scientific studies of the nutritional value of food ingredients have been used over and over again to sell the public on their need for particular products. Proteins, because of their very high nutritional value, rightly have been the subject of much of this advertising, and public awareness of its need for this food ingredient, in quantity, is very high today.

On the other hand, the bulging waistlines of some of our well-fed citizens, plus medical advice on dieting, have led many individuals to decrease their consumption of fat. Sales of high fat dairy products have decreased relative to sales of low fat dairy products.

Paradoxically, in the presence of a public desire and need for protein, milk, the product the public has been buying largely on a fat basis, contains the best balanced and least expensive of our major food proteins. Unfortunately, most protein advertising has been directed toward the sale of foods other than those derived from milk and not until the last few years have references to milk proteins appeared regularly in dairy advertising. The dairy industry is becoming increasingly aware of this paradox and is shifting its attention to the advertising of this more valuable and, in our present price structure, less expensive ingredient, milk protein.

Already, in at least one country, breeding programs are aimed at increasing protein production. This changing situation may eventually exert a worldwide impact upon the dairy industry. In most areas where dairying is a major industry, scientists are busy trying out new practical tests for proteins, solids-not-fat, and total solids, anticipating that one of these may eventually occupy just as important a place in the industry as fat testing does today.

At the present time there is considerable difference of opinion from one country to another as to whether milk should be tested for protein, solids-not-fat, total solids, fat, or fat and protein combined. Proponents of each test claim greater eventual benefits to dairying. Regardless of which test wins out and becomes more prevalent and more accepted for its chosen purpose, sound decisions regarding the applications of these tests will not be possible until we obtain essential knowledge pertaining to the proteins and solids-not-fat content of our milk, and to the factors which affect the amounts produced.

The Ontario Department of Agriculture and Food, by its decision to financially support a milk composition study, gave assurance to the dairy industry that essential information on this subject would be obtained.

OBJECTIVES OF STUDY

The broad aims of the study were:

(a) To determine the effects of factors such as age of cow, stage of lactation, season of year, breed, incidence of mastitis, line of breeding, etc, upon the protein, lactose, fat and gross solids-not-fat content of milk from individual cows. In addition, the interrelationships between the various milk constituents would be studied.

(b) To determine the accuracy and practicability of newly proposed tests for protein and solids-not-fat.

(c) To determine the average composition of milk produced in Ontario from samples taken from milk plants throughout the province.

PROCEDURE OF STUDY

Individual Cow and Herd Milk Samples

Prior to July 1961, 20 herds (five of each of the Ayrshire, Guernsey, Holstein, and Jersey breeds) were selected within a 25 mile distance of Guelph. The herds were all purebred and had been on official milk recording (R.O.P. — Record of Performance) with a minimum of 20 milking cows. An attempt was also made to select herds where the owners exhibited an interest in the project, and where artificial breeding was being used to some extent. In order to assure continuity throughout the three year study, herds were selected, as far as possible, on the basis that the owners did not have any immediate plans for dispersal of the dairy operation.

All milk samples from the 20 herds plus the dairy herd at the Ontario Agricultural College were tested for fat by the same R.O.P. inspector throughout the course of the study. By February 1962, laboratory procedures had been streamlined to the extent that a second group of twenty herds was included on the project. These herds were located north of Toronto in the Maple-Newmarket area. In selecting these herds the same factors that were used in the Guelph area were applied, with the exception that slightly larger herds (30-40 cows) were accepted.

Milk samples from individual cows were taken at the time of milking, at the farm by R.O.P. inspectors. Samples from evening and morning milkings were combined. The relative amounts taken at each milking were adjusted to the relative amounts produced by the cow at each milking. Mixing was accomplished by pouring back and forth from one bucket to another and the aliquots were then transferred to the sample bottles with a one ounce sampling dipper. Where pipeline milking installations were used the morning and evening samples from the automatic sampling devices were combined and mixed. The volume required for testing was then transferred to the sample bottle. The samples were kept in refrigerated sample cases until they reached the laboratory. One R.O.P. inspector brought the samples to the laboratory and carried out the fat tests there. The other inspector took duplicate samples, carried out the fat test on one of these at the farm, and forwarded the other to the laboratory.

Milk samples were transported, Monday to Friday inclusive, to the Dairy Science Department of the Ontario Agricultural College by 11 a.m. by the R.O.P. inspector in the case of the Guelph herds and by employees of the Central Ontario Cattle Breeding Association for the Toronto area herds. All the standard procedures associated with the sampling, recording, etc, of herds on official testing were applied to the 40 herds used in the project. The testing for butterfat percentages was conducted at the Dairy Science Department by an R.O.P. inspector instead of at the farm as in the usual procedure.

Approximately 1,400 cows fairly evenly divided among the four breeds were involved in the study. In general, the herds chosen were somewhat above breed average for milk production, however it was felt that in general the herds were good representations of the breeds involved.

Fluid Milk Plant Milk Samples

Since the composition of milks obtained from only registered cows and from only two areas of the Province could not be considered representative of the composition of all milk in the Province, one part of the study was devoted to the analysis of milks obtained from milk plants at various locations in the Province. An attempt was made to obtain samples from each participating plant twice each month for a period of one year. Participat-

ing plants included one at Ottawa, one at Kingston, two at Toronto, one at Barrie, one at Guelph, two at London, three at Windsor and one at Fort William. At plants where the milks received were separated into categories described as standard and special, both types were sampled.

As each sample obtained at a plant represented a very large volume of milk, it was hoped that any compositional differences due to area would become apparent during the course of the year. Also, by comparing plant milks and herd milks with respect to seasonal changes in composition, it was hoped to establish whether or not the seasonal changes in composition of herd milks were characteristic of the milk supply as a whole. With respect to the separation of standard and special milks, it was expected that standard milks would be more representative of the milks of the Holstein and Ayrshire breeds, whereas special milks would be more representative of milks of the Guernsey and Jersey breeds.

At most plants, the intake of milk for one day represented the milk produced by only one-half of the patrons shipping to that plant. Therefore, the two sampling days per month were chosen so that each of the two samples represented the milk produced by a different group of patrons. For the first two sampling periods, the sampling was supervised by fieldmen from the Dairy Branch of the Ontario Department of Agriculture and Food. Thereafter, the samples were procured by personnel at the various plants. The eight ounce samples so obtained were shipped to the Guelph laboratory in a specially designed shipping container. It consisted of an inner container of polystyrene held in a corrugated carton. The inner container was manufactured from a ten inch cube of solid polystyrene with openings just large enough to take a one quart ice pack and two eight ounce sample bottles. This was covered with a polystyrene lid. Preliminary experiments were conducted in order to be sure that the milk shipped in this container would be held below 50°F for at least 48 hours, as this was the longest period of shipment required. The container proved to be quite adequate, and all samples arrived at the laboratory in excellent condition.

The samples obtained were analyzed for fat, protein, lactose, solids-not-fat and total solids. In addition, a leukocyte count and the California mastitis test were conducted on each sample.

ANALYTICAL METHODS

Because of the large number of milk samples to be analyzed, it was realized that for some components the use of official methods would result in an excessively high cost for the study. As a result, practical methods were used wherever they were considered suitable. At the same time the degree of relationship between these practical methods and the official methods was determined, to assess the accuracy of the results.

The percentage fat was estimated by the official Babcock method. The percentage protein was estimated by a dye binding method using Amido Black 10B Dye. As this was not an official method for protein analysis, a semimicro Kjeldahl procedure was also used on some of the daily samples. The Kjeldahl results were used to determine the appropriate factors to use in calculating percent protein from the dye binding data, and to determine the degree of correlation between the two methods. The percentage lactose was estimated by a polarimetric method, and its accuracy was assessed by determining the percentage recovery of lactose from milk samples containing added lactose. The percentage total solids was estimated by a gravimetric procedure which first was compared with the official method for estimation of total solids in milk. The percentage solids-not-fat was estimated by subtracting the percent fat from the percent total solids. At the beginning of the study the percentage solids-not-fat was also estimated by the "Golding" bead method. This method was at the time in the early stages of its development, and as the results obtained were not considered satisfactory, its use was discontinued.

The Infra Red Milk Analyzer (IRMA), purchased by the Ontario Department of Agriculture and Food in 1964, was included in the last year of the study and appraised as an updated, practical method for determining the fat, protein and lactose content of milk.

The precisions of all the methods used were calculated from the results of repeated analyses carried out each day on some of the samples of the previous day. Estimates of precision therefore were available for the entire period of the study.

CONCLUSIONS FROM STUDY

1. For field testing the Babcock method of butterfat estimation still remains a very satisfactory procedure.

2. For central laboratory testing of milk for butterfat content, Infra Red Milk Analyzer (IRMA) using standard Mojonnier analysis for calibration control is recommended over the Babcock method on the basis of speed and accuracy of testing. This applies to any raw, pasteurized or homogenized sample of whole milk.

3. For the estimation of protein content of milk, IRMA with calibration control by the standard Kjeldahl method under central laboratory conditions is recommended over the Amido Black Dye binding method for all purposes. The Amido Black method is satisfactory for bulk milk samples providing calibration is controlled by the standard Kjeldahl method. Due to the variation of dye binding capacities of whole milk protein, the Amido Black method is not recommended for analysis of individual cow milks. At present, there is no satisfactory field test for protein.

4. For the estimation of lactose content of milk, IRMA is the only practical and satisfactory instrument available. Calibration can be controlled by the polarimetric method described in this report.

5. Solids-not-fat can best be estimated by totalling the protein and lactose results obtained by IRMA and a constant representing the other non-fat components of milk. The Golding Bead method for solids-not-fat estimation is not recommended.

6. For the determination of total solids of whole milk the procedure of totalling fat, protein and lactose percentages as determined by IRMA and a constant is quite satisfactory. No satisfactory field test exists for total solids.

7. A sampling frequency of once per 15-day period will give adequate estimates of annual butterfat percentage for producer milk and of monthly butterfat percentage for plant milk. Although sampling frequency was not studied for the other milk components, there is no reason to believe that more frequent sampling would be required.

8. Since seasonal and breed variations in composition were similar in both plant and herd samples, it is reasonable to assume that such variations are common to all herds in Ontario (Figures 1-8, Tables 1 and 2).

9. It was found that for an increase of one unit of California Mastitis Test (C.M.T.) value the following average changes occurred: lactose concentration in the milk decreased 0.100%, solids-not-fat (S.N.F.) decreased 0.046%, protein increased 0.042% and monthly milk production decreased 49 lbs per cow. There was no effect on the butterfat test. These changes were independent of the effects of age of cow, stage of lactation and month of year.

10. Based on the distribution of C.M.T. reactors in the herds in this study and using a 40 cow herd with the same kind of distribution, one would expect a loss of 1,470 lbs of milk per month compared with a herd without reactors and lactose, and S.N.F. percentages would be depressed from 4.75 to 4.67 and from 8.94 to 8.90 respectively, while protein percentage would increase from 3.70 to 3.73.

11. The four dairy breeds used in this study will rank in the same order for all milk components, expressed as percentages, except lactose which exhibits little variation from one breed to another (Table 3).

12. The effect of season of calving on percentage composition does not appear to be sufficiently large to warrant record adjustment.

13. The lactation curves for protein, total solids and solids-not-fat have the same general shape as the curve for butterfat with the low point falling in the 60- to 120-day period following calving, after which there is a gradual increase towards the end of lactation. Lactose percentages tend to have the same general shape as the lactation curve for milk volume but with a much reduced degree of variation. The percentage of lactose decreases gradually throughout the lactation after reaching a high peak 60 to 90 days following calving (Figures 9-14).

14. In general, the percentage composition of milk reduces slightly and in a fairly linear manner with advancing age. The reduction with age

is so slight that record adjustment does not appear necessary. Age effect for milk volume is considerable, appears curvilinear and hence all records should be adjusted for this variable. This would also apply if the various components were expressed in terms of volume or weight rather than in percentages.

15. Correlation coefficients are estimates of the degree of relationship among different variables which in this study were milk volume and percentages of milk components. Several inferences can be drawn from the relationship, such as:

    (a) The relatively high correlation between solids-not-fat and total solids with percent butterfat indicates that these two composite milk components can be adequately estimated from butterfat percent and therefore need not be tested for. The high correlation between percentage butterfat and total solids in particular clearly indicates that the present method of testing milk for butterfat percentage is quite adequate for estimation purposes should the knowledge of total solids be required.

    (b) The relatively low relationship between protein and lactose indicates that it is inadvisable to test for solids-not-fat as a routine procedure for evaluating cows. Since protein and lactose are the primary components of solids-not-fat, there is no real way of estimating protein percent from solids-not-fat values. A system of evaluating milk for solids-not-fat is not recommended.

    (c) The positive correlation of medium magnitude between protein and butterfat percent indicates that by selecting for butterfat percentage, dairymen have also been selecting to a limited degree for protein percentage. If protein were to become the desired component in milk, it would be advisable to test and select directly for it rather than indirectly through butterfat (Table 4).

16. The repeatability values obtained in this study were slightly greater than the majority of values for the same traits reported in the literature. In the prediction of future records of milk components and milk volume it should be realized that the reported repeatability values from this study will likely yield optimistic estimates. Nevertheless, one record of milk composition for any of the components expressed as a percentage and based on a 305-day lactation will yield quite reliable estimates of future records on the same cow.

17. The fairly smooth shape of the lactation curves and the magnitude of the repeatability values based on monthly tests within the same lactation clearly indicate that once per month testing will give quite reliable estimates of lactation totals.

18. The heritability estimates based on an intraherd daughter-dam regression analysis are fairly high for all of the milk components when expressed on a percentage basis, with the exception of the Guernsey breed which could in this case be the result of the sample studied. It has been well established that considerable progress can be made in the raising of butterfat percentage through effective selection and breeding programs. Since the heritability estimates for the other milk components are similar, it is reasonable to expect somewhat similar rates of genetic improvement in these with equal selection pressure, although in certain cases the variation existing is less. This could result in a restriction on the amount of selection pressure that would be applied.

Figure 1

Seasonal Variations of Average Fat, Protein and Lactose Percentages in Standard Milk Received at Market Milk Plants in Ontario.

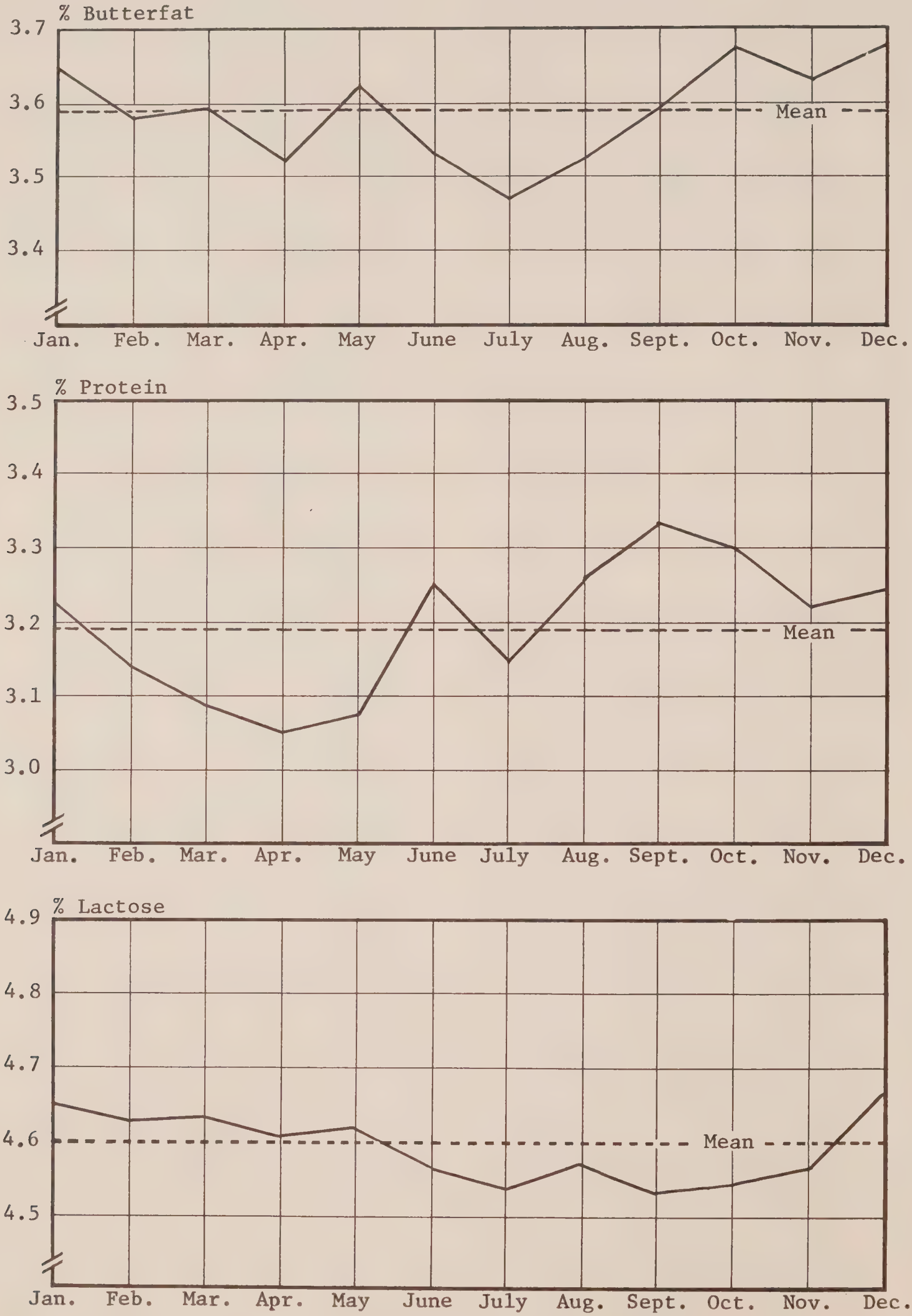


Figure 2

Seasonal Variation of Average Total Solids and Solids-not-fat Percentages in Standard Milk Received at Market Milk Plants in Ontario.

Figure 3

Seasonal Variations of Average Fat, Protein and Lactose Percentages in Special Milk Received at Market Milk Plants in Ontario.

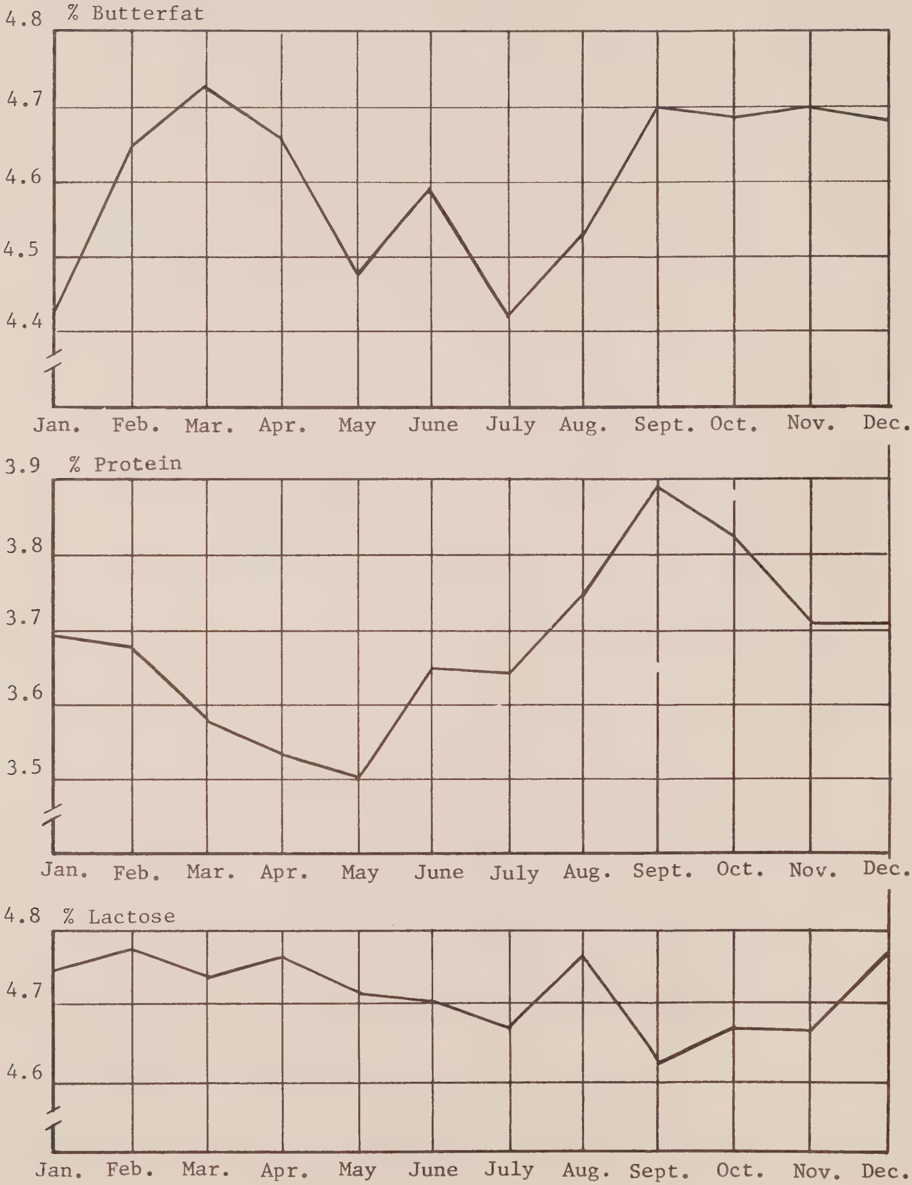
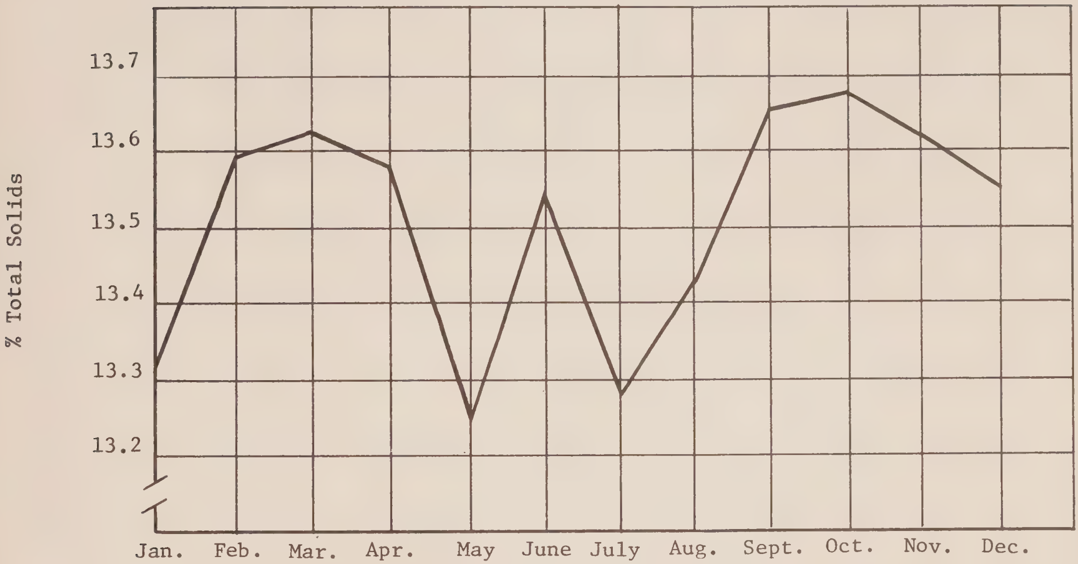


Figure 4

Seasonal Variations of Average Total Solids and Solids-not-fat Percentages in Special Milk Received at Market Milk Plants in Ontario.



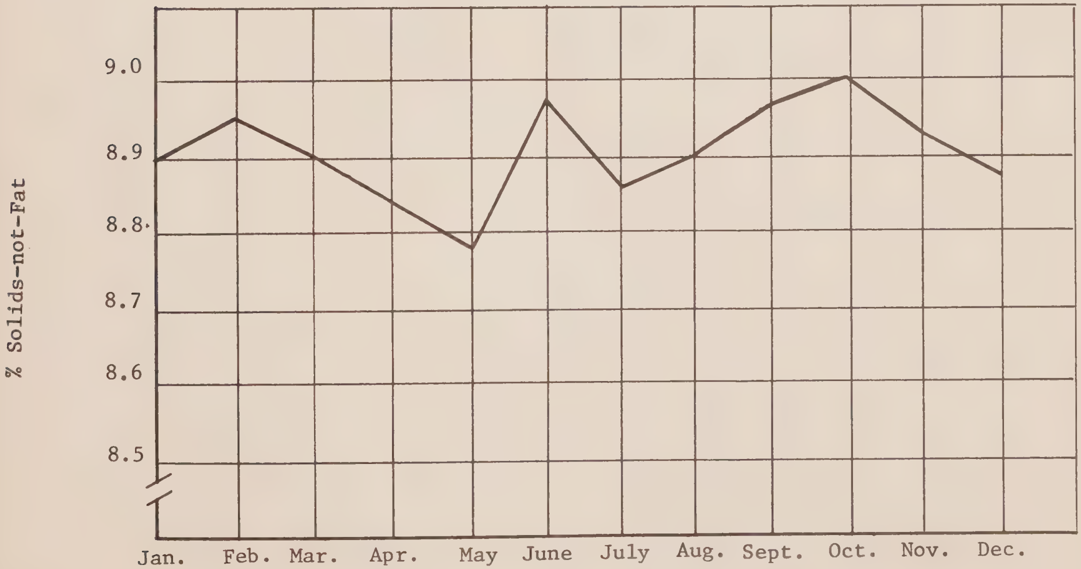


Figure 5

Seasonal Variations of Average Fat, Protein and Lactose Percentages in Ayrshire and Holstein Herd Milks.

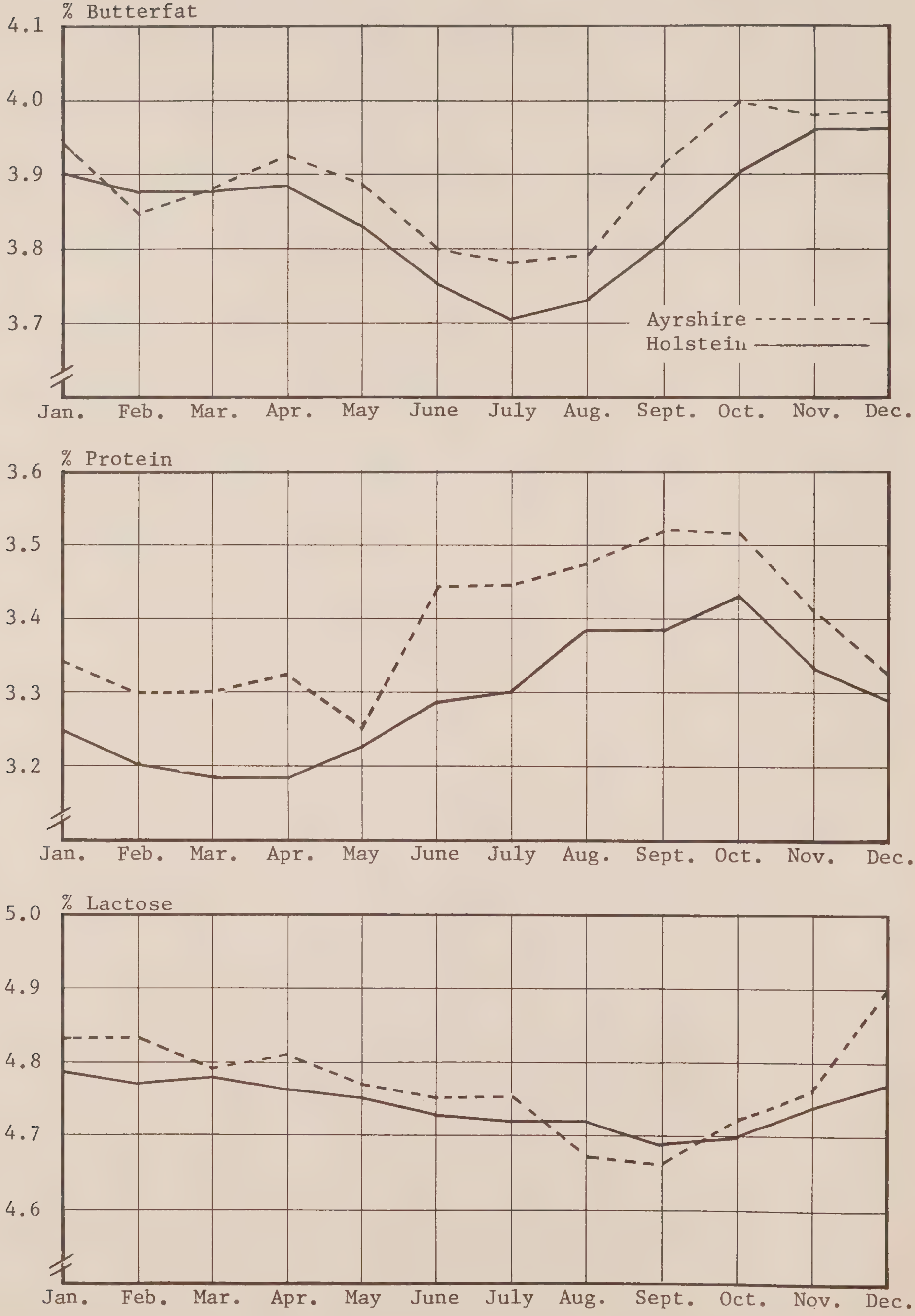


Figure 6

Seasonal Variations of Average Total Solids and Solids-not-fat Percentages in Ayrshire and Holstein Herd Milks.

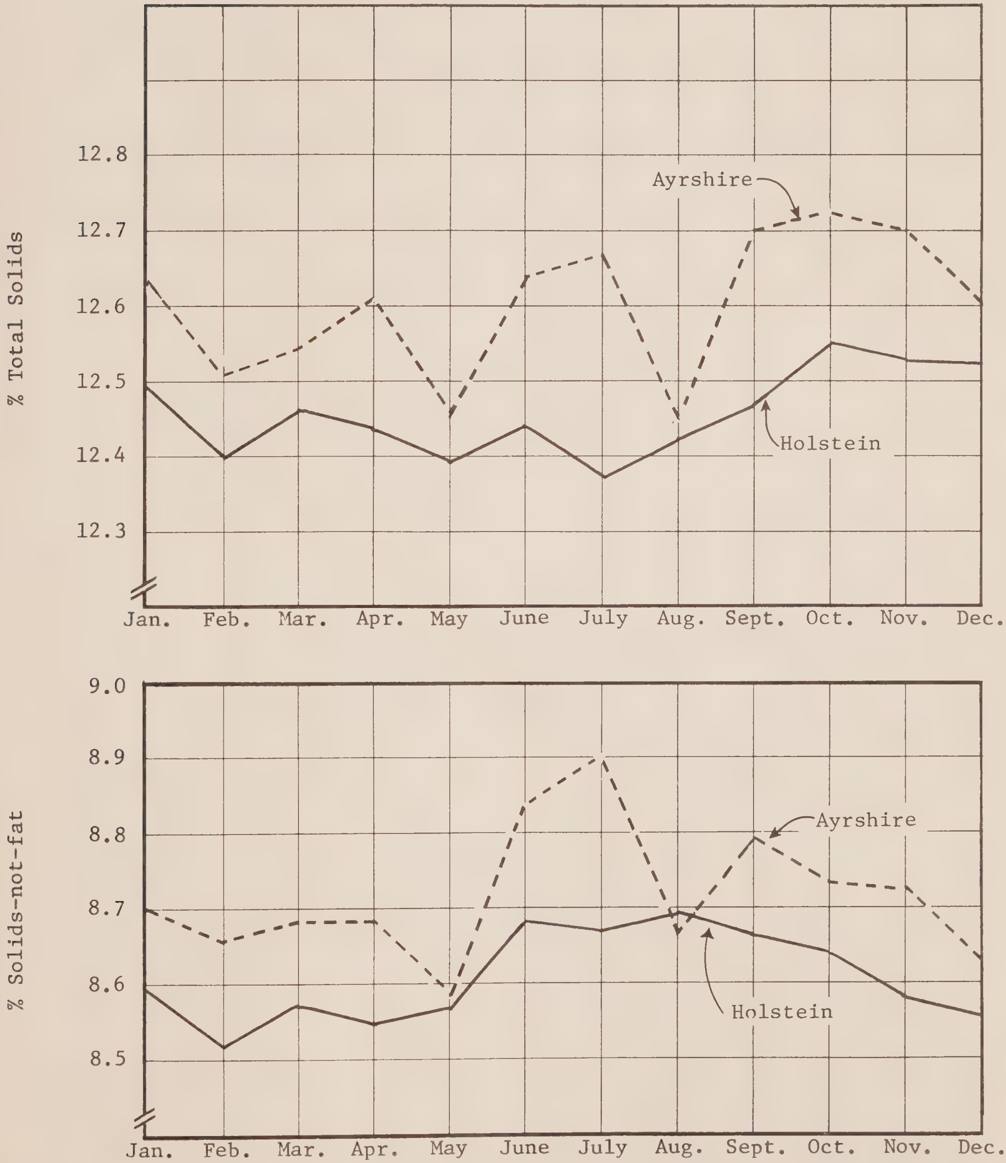


FIGURE 7

Seasonal Variations of Average Fat, Protein, and Lactose Percentages in Guernsey and Jersey Herd Milks.

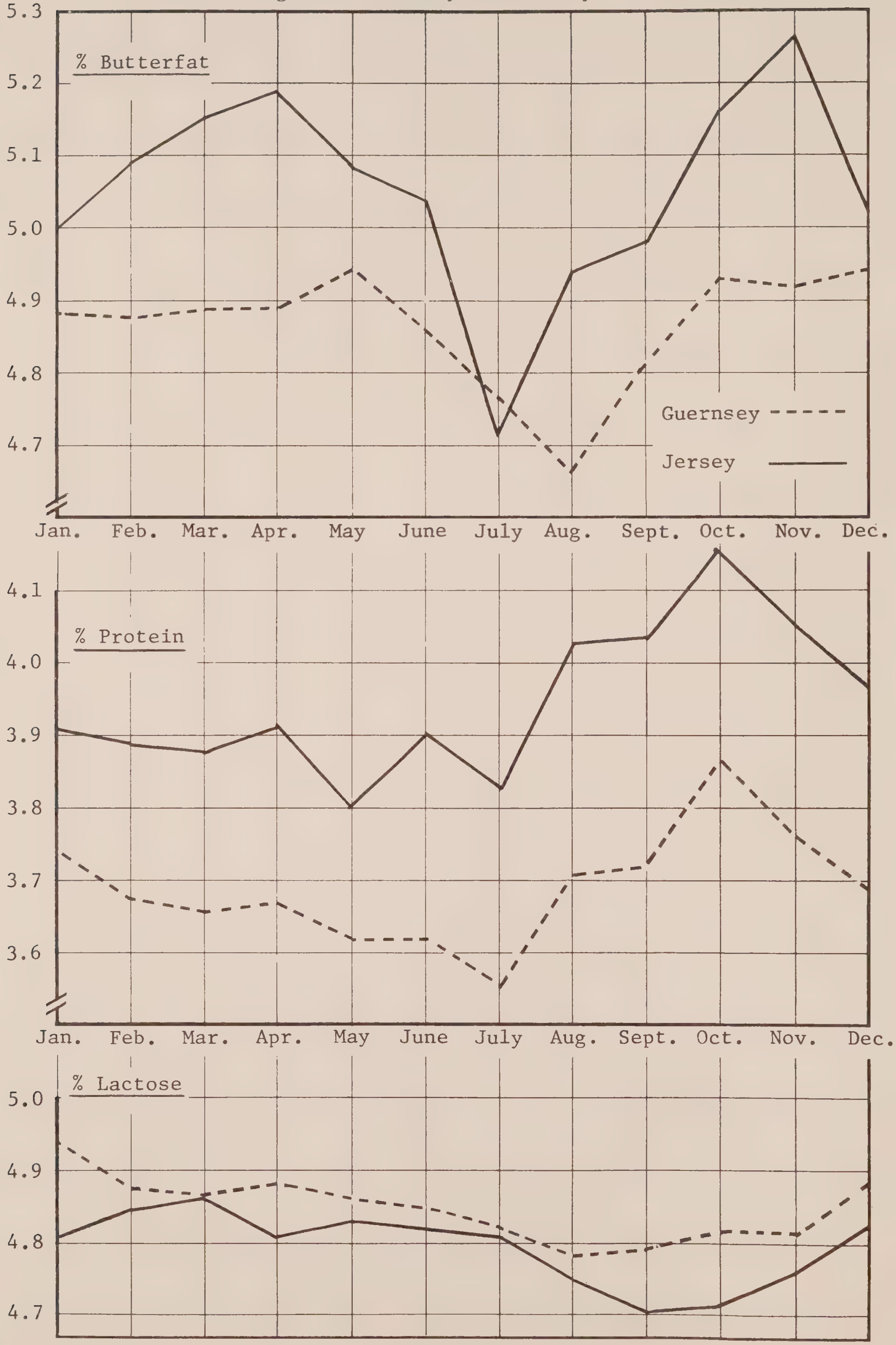
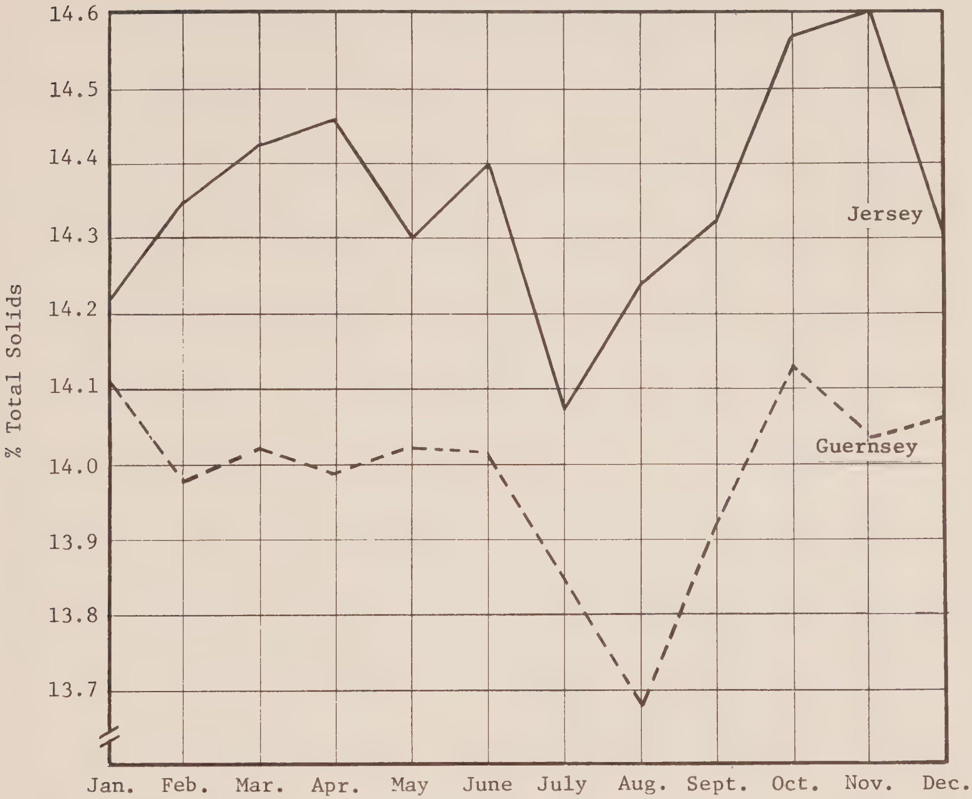


FIGURE 8

Seasonal Variations of Average Total Solids and Solids-not-fat Percentages in Guernsey and Jersey Herd Milks.



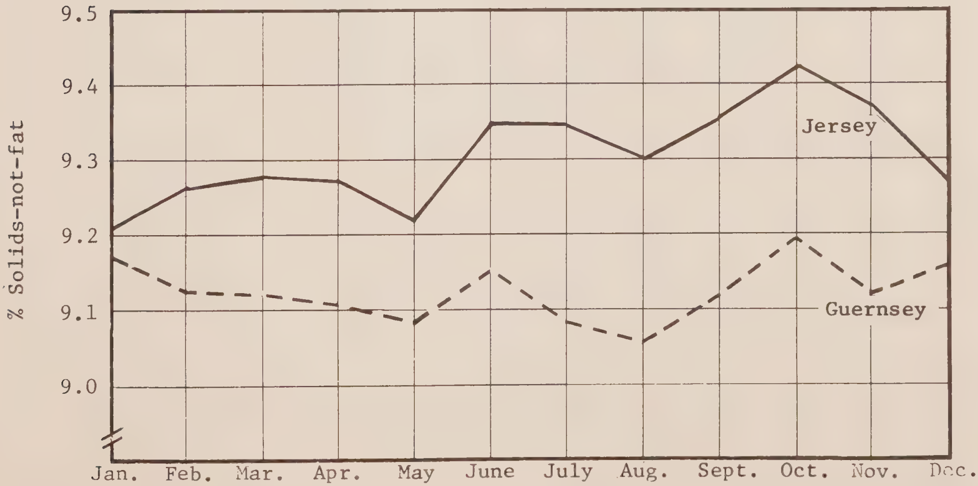


Figure 9

Average Milk Production at Successive Stages (30-day intervals) of Lactation

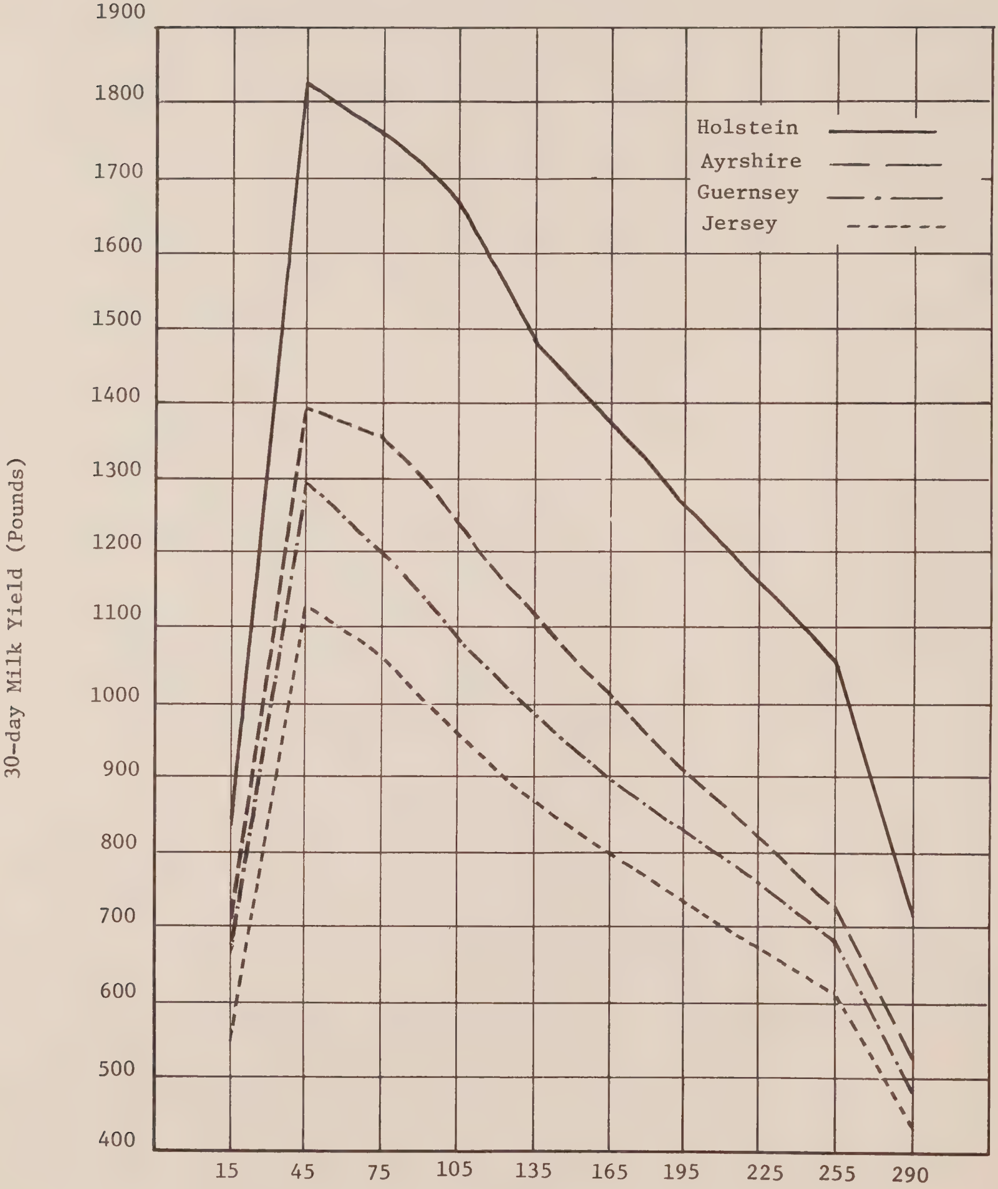


Figure 10

Average Percentage Butterfat at Successive Stages (30-day intervals) of Lactation

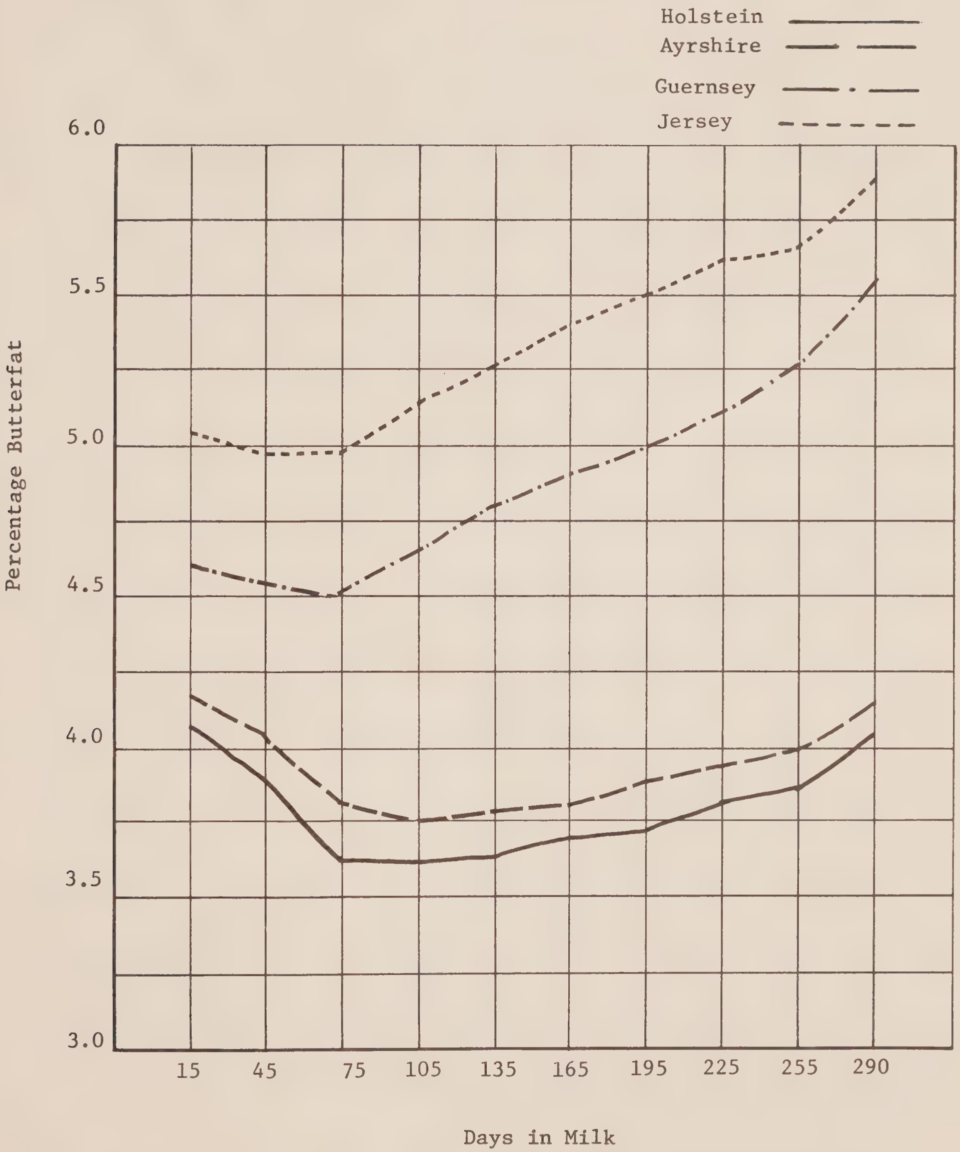


Figure 11

Average Percentage Protein at Successive Stages (30-day intervals) of Lactation

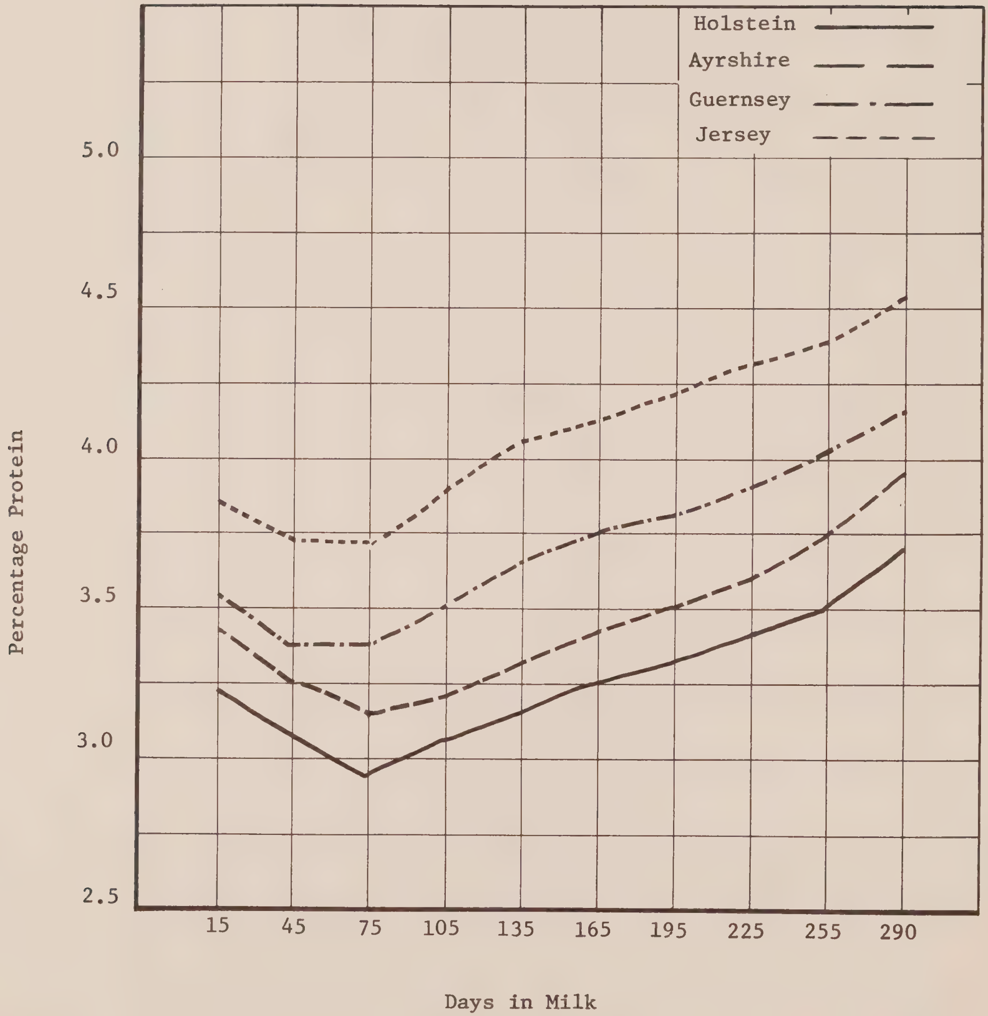


Figure 12

Average Percentage Lactose at Successive Stages (30-day intervals) of Lactation

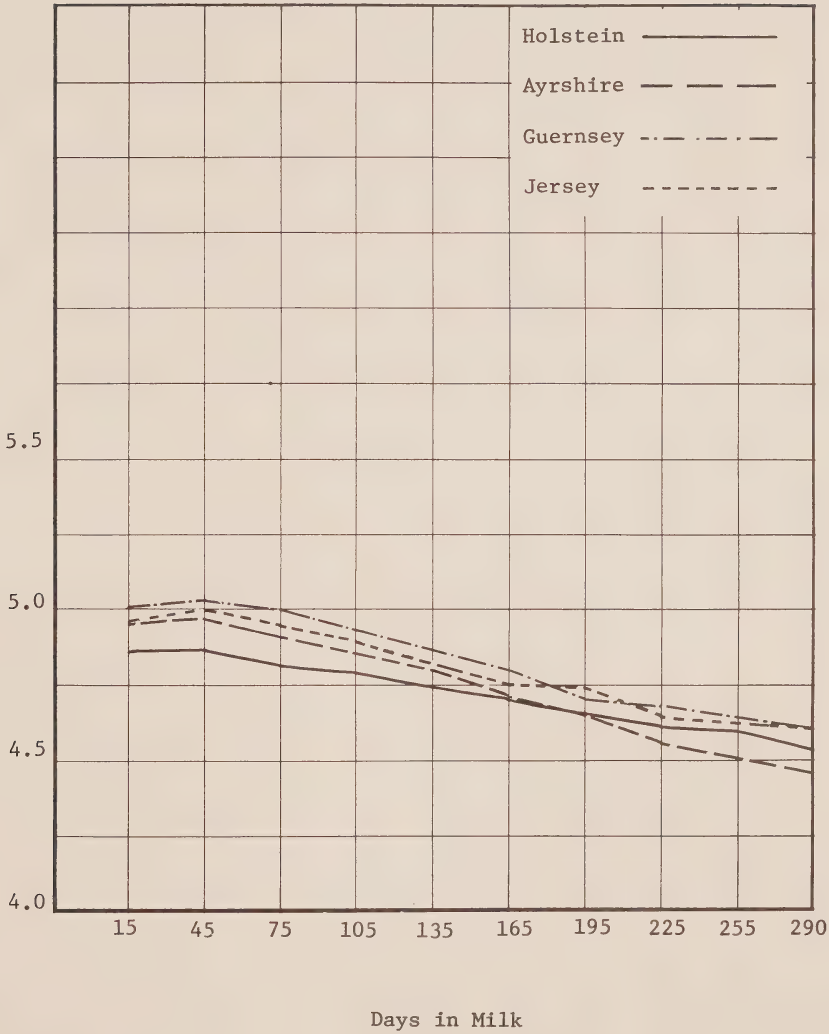


Figure 13

Average Percentage Total Solids at Successive Stages (30-day intervals) of Lactation

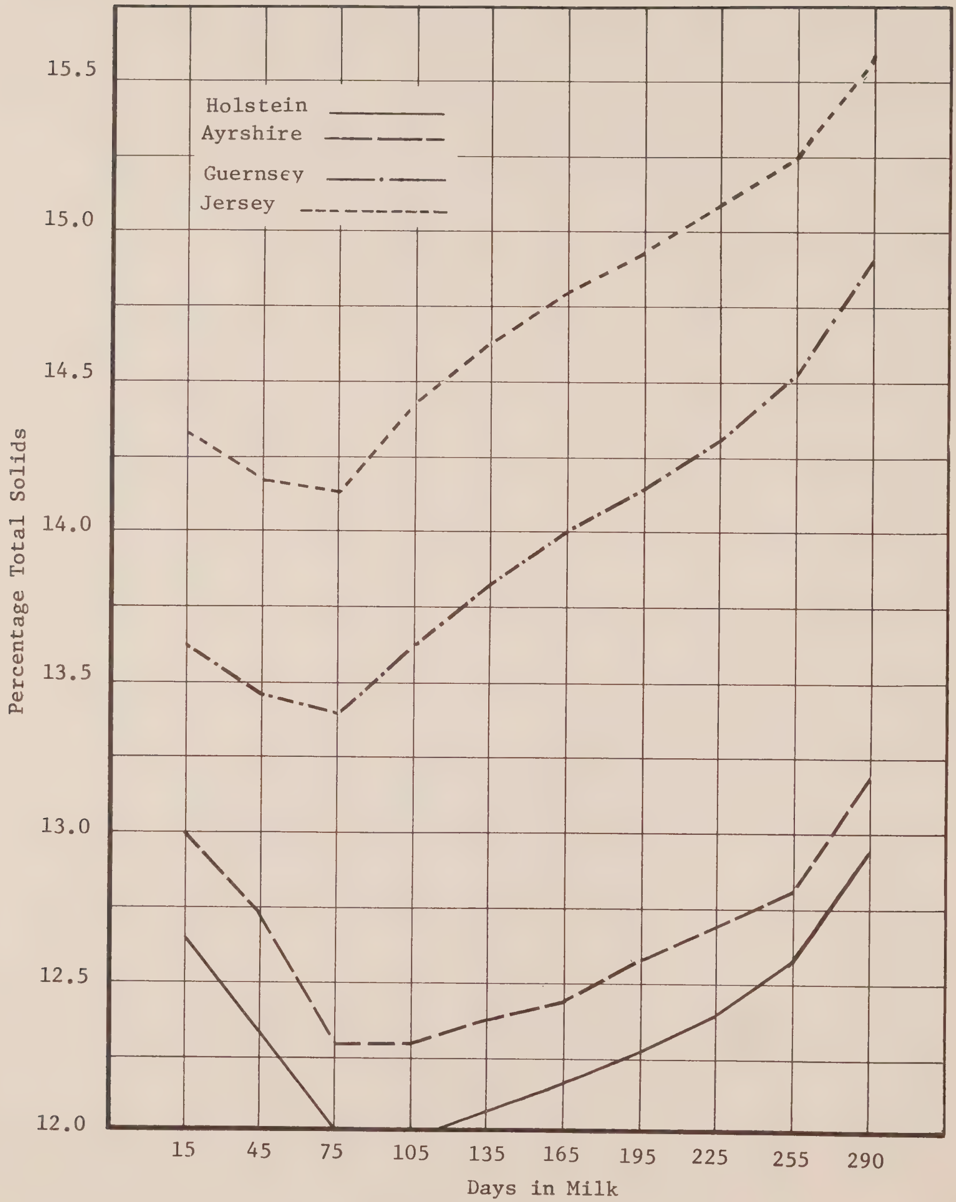


Figure 14

Average Percentage Solids-not-Fat at Successive Stages (30-day intervals) of Lactation

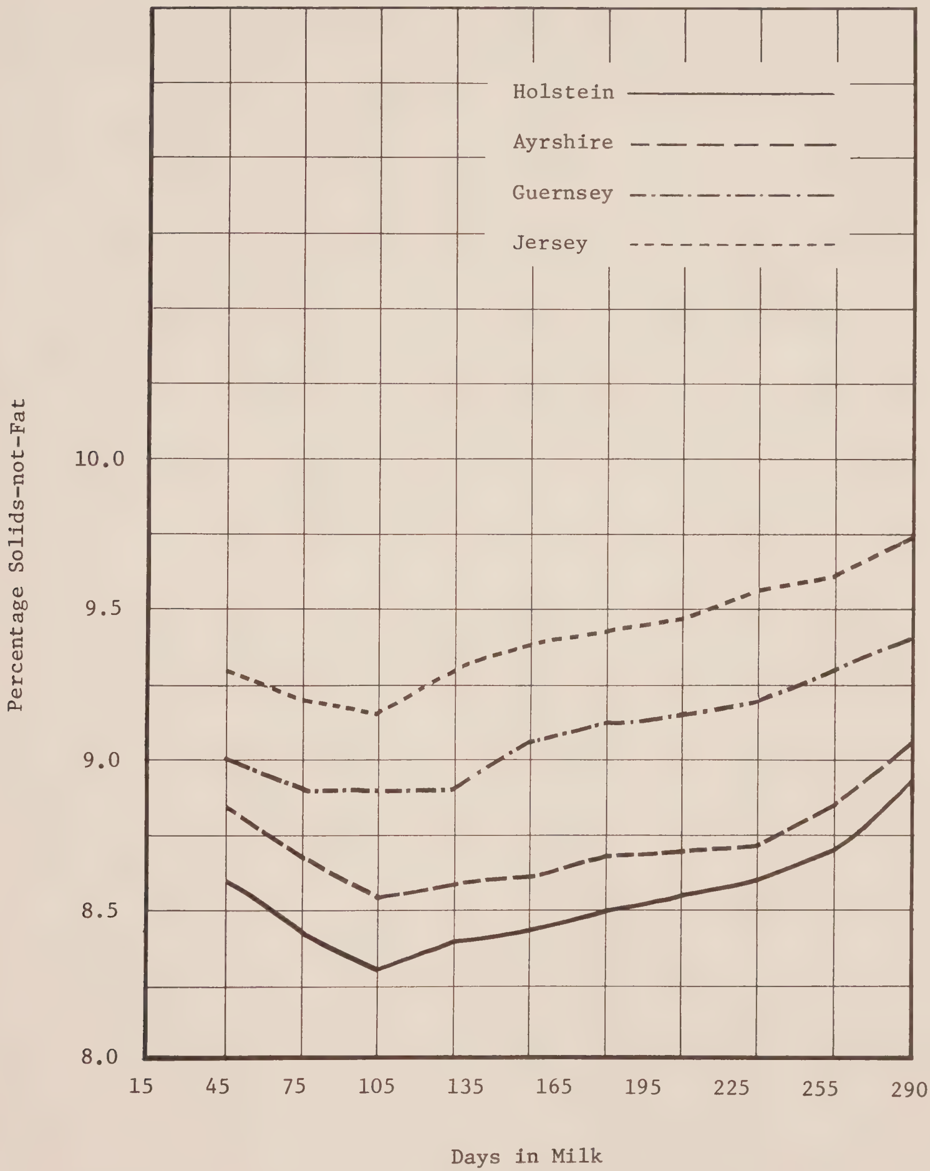


TABLE 1

AVERAGE COMPOSITION OF PUREBRED HERD MILK FROM FOUR DAIRY BREEDS FOR THE PERIOD JULY 1961 TO JULY 1965

	Ayrshire (327 samples)	Guernsey (323 samples)	Holstein (454 samples)	Jersey (364 samples)
Fat	3.89%	4.88%	3.85%	5.07%
Protein	3.38	3.69	3.29	3.94
Lactose	4.77	4.85	4.74	4.80
Total Solids	12.60	13.99	12.46	14.36
Solids-not-fat	8.71	9.13	8.61	9.30

TABLE 2

AVERAGE COMPOSITION OF STANDARD AND SPECIAL MILK RECEIVED AT TWELVE ONTARIO MILK PLANTS DURING 1963

	Standard Milk (216 samples)	Special Milk (100 samples)
Fat	3.59%	4.61%
Protein	3.18	3.67
Lactose	4.58	4.72
Total Solids	11.89	13.52
Solids-not-fat	8.31	8.91

TABLE 3

BREED AVERAGES FOR POUNDS OF MILK AND % MILK COMPONENTS ON THE BASIS OF 305-DAY LACTATIONS

Breed	No. of Lac.	Pounds of Milk	Fat %		Total Solids %	
		mean	mean	range	mean	range
Jersey	927	8124	5.24	3.7 – 7.1	14.61	12.7 – 17.1
Guernsey	928	9154	4.82	3.7 – 6.9	13.87	11.7 – 15.9
Ayrshire	791	10256	3.88	2.9 – 4.9	12.58	10.3 – 14.5
Holstein	954	13814	3.75	2.7 – 4.9	12.27	10.2 – 14.5

Breed	No. of Lac.	Solids-not-fat %		Protein %		Lactose* %	
		mean	range	mean	range	mean	range
Jersey	927	9.35	8.4 – 9.9	4.03	3.3 – 5.1	4.81	4.0 – 5.2
Guernsey	928	9.05	7.8 – 9.9	3.66	2.9 – 4.3	4.84	3.8 – 5.2
Ayrshire	791	8.70	7.2 – 9.7	3.41	2.6 – 4.3	4.77	3.4 – 5.4
Holstein	954	8.51	7.3 – 9.6	3.23	2.9 – 4.4	4.73	3.9 – 5.2

* Lactose averages based on 862 Jersey lactations, 878 Guernsey lactations, 737 Ayrshire lactations and 897 Holstein lactations.

TABLE 4

CORRELATION COEFFICIENTS FOR
MILK VOLUME AND VARIOUS MILK COMPONENTS (%)
305-day Lactations

Variables	Breed			
	Ayrshire	Holstein	Guernsey	Jersey
Milk — fat	–.04	–.12	–.16	–.08
Milk — total solids	–.06	–.20	–.16	–.11
Milk — solids-not-fat	–.07	–.23	–.10	–.15
Milk — protein	–.23	–.23	–.16	–.10
Milk — lactose	.11	–.12	.09	–.13
Fat — total solids	.83	.86	.91	.95
Fat — solids-not-fat	.39	.41	.49	.56
Fat — protein	.41	.54	.50	.66
Fat — lactose	.20	.12	.15	.03
Total Solids — solids-not-fat	.84	.81	.80	.79
Total Solids — protein	.68	.76	.67	.78
Total Solids — lactose	.55	.48	.38	.16
Solids-not-Fat — protein	.72	.76	.71	.77
Solids-not-Fat — lactose	.70	.72	.60	.36
Protein — lactose	.11	.21	.02	–.15

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